

# Climate Change and the Hydrologic Cycle

## Basics

- Any general heating would be expected to lead to a wetter world – though not quite ‘Waterworld’ – as evaporation and precipitation are both enhanced.
- Most of the predicted temperature increases would be expected in mid-continental areas which could lead to increased evaporation and decreased soil moisture
- IPCC (1990) concluded that in historical times, precipitation has increased in extra-tropical areas with a tendency for decreasing precipitation in the subtropics
- A problem is that the instrumental precipitation record is problematic as precipitation is much harder to accurately measure than temperature. There is probably some inflation in the measured precipitation simply because the instrumentation has improved through time, especially with regards to snowfall.
- The best evidence is for a slight 1% increase in global precipitation over the historical record.

## Trends (certainly not exhaustive)

- North America annual precipitation has increased this century. Autumn shows the greatest increases and a tendency for a higher percentage of precipitation to come in big storms.
- One of the longest instrumental records is from Scotland (1757-1992). It appears to be consistent back until 1869. This record shows increasing annual precipitation, especially during the 1970s. Summer precipitation is down.
- For Central and south America, a limited record and the drastically differing effects of El Nino across the region make it difficult to analyze long term trends.
- Since 1970s, the Asian monsoon in the Yantzee Valley of China has lacked an intense onset, but annual totals are still high
- The Sahel has been very dry this half century, though the last couple of years have had above average precipitation. Remember, there can be feedback loops between the atmosphere and land surface. Take for instance, the Sahel. Drier conditions mean less plants which means decreased transpiration which means less chance for water vapor to be recycled and reprecipitated. Human impacts such as desertification and

overgrazing may also lessen rainfall as has been suggested for SW Australia.

- If you think it is hard to measure precipitation over land, try over the ocean where there are very few long term sites. Satellites offer an increasingly better view of tropical precipitation, but the data record is limited temporally – it goes back to about 1979.
- There are three methods, all with problems, in measuring precipitation over the oceans:

1. HRC – highly reflective clouds

This is a subjective methodology where the amount of rainfall is related to the amount and reflectivity of clouds. It is limited in application to the tropics and subtropics, it does not adequately portray the diurnal cycle of clouds and suffers from poor resolution and satellite to satellite differences.

2. Cloud-top temperatures

This technique utilizes the relationship between rainfall and the temperatures of the cloudtops. It works in the tropics and subtropics, but suffers from satellite to satellite differences in cloud top temperature retrievals.

3. Microwave Sounding Unit

The best method currently used. It utilizes microwave emissions to determine the amount of water droplets. For a better description and a look at the Tropical Rainfall Monitoring Mission, NASA's newest mission to measure rainfall check out [trmm.gsfc.nasa.gov](http://trmm.gsfc.nasa.gov).

Early satellite estimates suggested an increase in tropical precipitation, but reanalysis suggests that much of the increase can be ascribed to differences between the satellites used in the studies.

## **Relationship between Temperature and Precipitation**

There is a strong low frequency relationship between land-based temperature and precipitation. In the mid- to high-latitudes of the Northern Hemisphere, increasing temperatures appear to be related to increasing precipitation. In the subtropics and mid-latitudes of the Southern Hemisphere the inverse appears to be true, with higher temperatures leading to lower precipitation.

## **Snow Cover, Snowfall and Snow Depth**

Over the past 21 years snow cover over the Northern Hemisphere has decreased. This decrease is particularly evident in springtime, but more recently has appeared in autumn and summer as well. The decrease in snow cover is closely related to temperatures and the snow radiation feedback mechanism may be able to account for 50% of the springtime temperature

increase in spring temperatures. It may also explain why spring warming is more significant than warming at other times of year in the historical record.

Snow depth has increased over N. Canada and Alaska since 1950. Won't go into changes in the rest of the world...

## **Water Vapor**

Various sites seem to show that water vapor in the atmosphere has increased as well, but too little data and analysis to be conclusive.

## **Clouds**

Seem to be generally increasing as well.

## **Sea level**

Over the past 100 years sea level has risen 10-25 cm. Over this time there has been no detectable increase in the rate of sea level rise. This rise is due to several factors

- Global warming. An increase in average temperature should cause thermal expansion of the oceans (2-7 cm)
- Higher temperatures should increase the melting of the world's small alpine glaciers (2-5 cm)
- Major Icesheets of Greenland and Antarctica. In greenland warmer temperatures could lead to greater melting on the margins, but higher accumulations in the center. For Antarctica, higher temperatures would be expected to lead to increased accumulation. At this point there is not enough data to tell whether these ice sheets are presently gaining or losing mass.
- Surface and Groundwater – again not enough data to constrain the situation.